

(12) UK Patent Application (19) GB (11) 2 1 1 1 1 3 6 A

(21) Application No 8137181

(22) Date of filing

9 Dec 1981

(43) Application published

29 Jun 1983

(51) INT CL³ F16C 25/06

(52) Domestic classification

F2A 5C7 5CQ 7D5 D14

(56) Documents cited

GB 1385749

GB 1000355

GB 0725738

GB 0437699

(58) Field of search

F2A

(71) Applicant

Rolls-Royce Limited

(Great Britain)

65 Buckingham Gate

London SW1E 6AT

(72) Inventor

John Dominy

(74) Agent and/or Address for

Service

M A Gunn

Patents Department

Rolls-Royce Limited

P O Box 31

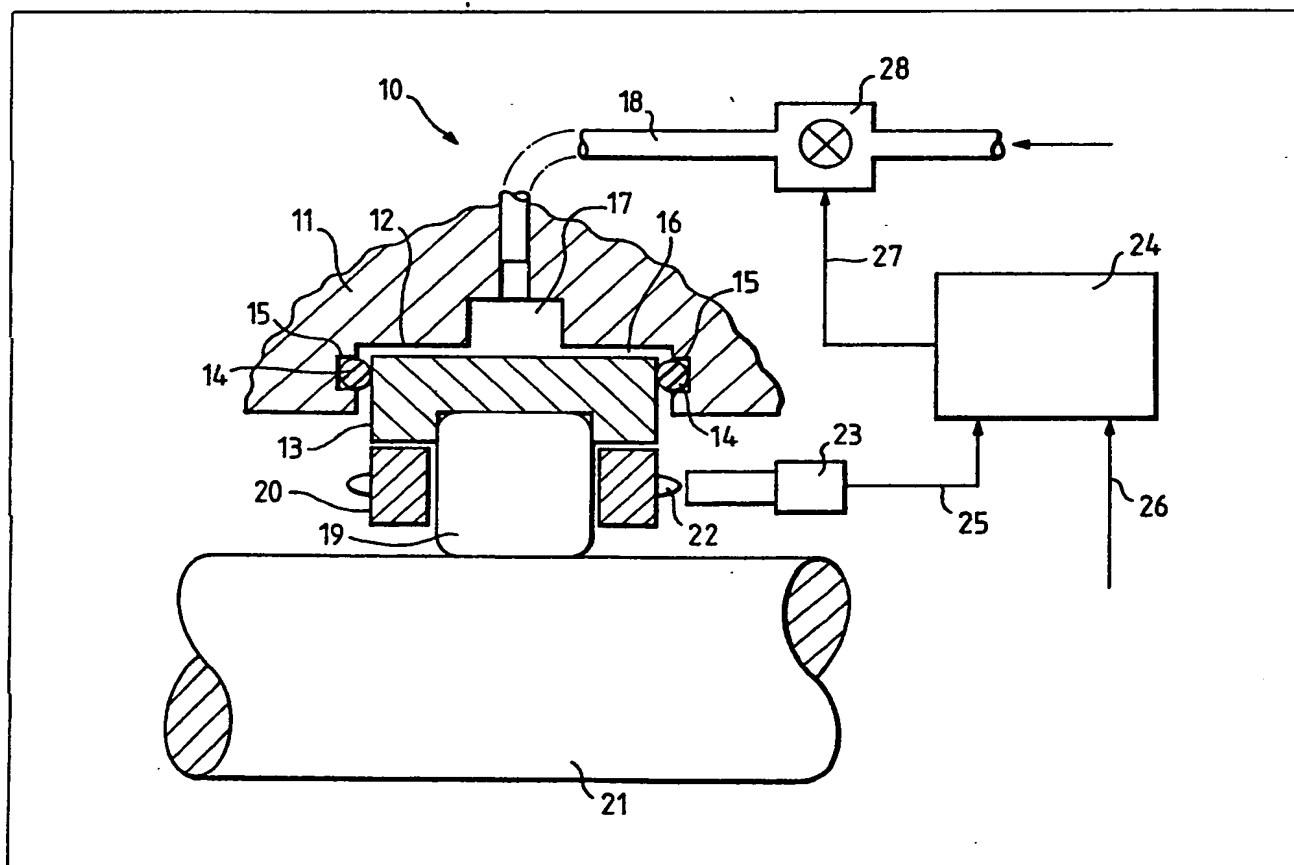
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to reduce or substantially eliminate the skidding.

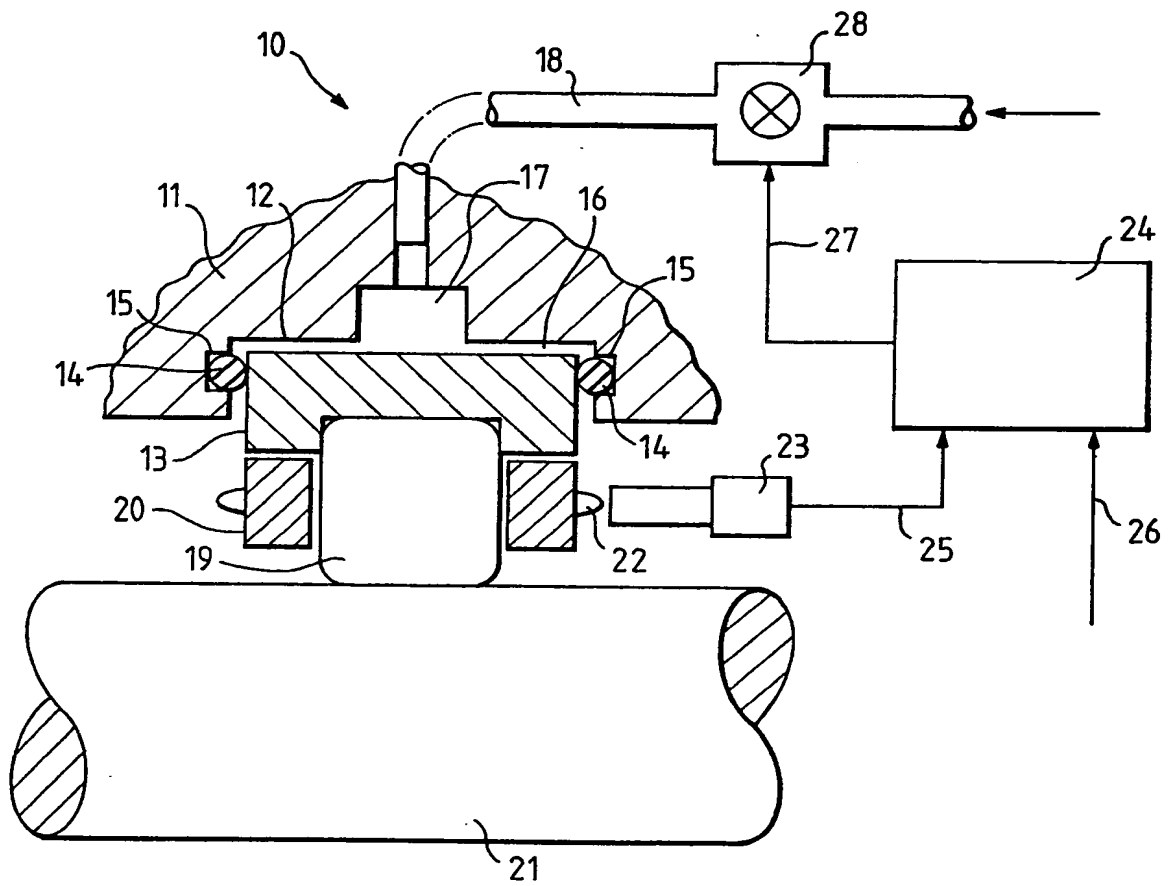
(54) Skid control in rolling bearings

(57) A ball or roller bearing assembly (10) includes an outer race (13) which is radially supported and damped by a squeeze film (16). The oil flow rate through the squeeze film (16) is controlled by a servo valve (28) in the oil supply duct (18) in accordance with the degree of skidding between the balls or rollers (19) and the bearing inner race (21). The oil flow rate is controlled so that radial thermal gradients are established within the bearing assembly which cause sufficient thermal contraction of the component parts of the bearing assembly



The drawing originally filed was informal and the print here reproduced is taken from a later filed formal copy.

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SPECIFICATION

Bearing skid control

5 This invention relates to the control of skidding in ball and roller bearing assemblies.

Ball and roller bearings, particularly those which are required to operate at high rotational speeds, are prone to skidding, that is, 10 relative sliding movement between the balls or rollers of the bearing and the surfaces which they engage. Such skidding is highly undesirable in view of the bearing damage which it causes and it can, in certain circumstances, 15 lead to bearing failure. Skidding is known to increase with the magnitude of the radial clearances between the various components of a bearing and consequently previous attempts to reduce skidding have centered around the 20 reduction of these radial clearances by appropriate dimensioning of the component parts of the bearing. However this is expensive to achieve, only applies to one condition and frequently fails to work.

25 It is an object of the present invention to provide a ball or roller bearing assembly in which continuous control of bearing clearances, and hence skidding, is provided.

According to the present invention, a ball or 30 roller bearing assembly comprises an array of balls or rollers interconnected by a cage and mounted between radially inner and outer races, said radially outer race being adapted to be cooled by a cooling fluid, regulating 35 means to regulate the rate at which cooling fluid is supplied to said radially outer race, means adapted to detect, and indicate by means of an output signal, the occurrence of skidding between said balls or rollers and one 40 of said races and control means associated with said skid detection means and said cooling fluid flow regulating means, said control means being adapted to control said fluid flow regulating means in accordance with the output signal from said skid detection means so 45 that cooling fluid is supplied to said radially outer race at a rate which is consistent with radial thermal gradients being established within said bearing assembly which cause 50 sufficient thermal contraction of the component parts of said bearing assembly to reduce or substantially eliminate said skidding.

Said radially outer race is preferably supported by a structure so adapted that an 55 annular chamber is defined between them, said annular chamber being fed with said cooling fluid and so configured that said cooling fluid defines a squeeze film which constitutes the sole means or radial support between said radially outer race and said support 60 structure.

Said cooling fluid is preferably an oil.

Said skid detector means may comprise means adapted to monitor the rotational 65 speeds of said cage and one of said races and

to compute therefrom the magnitude of any skidding between said race and said balls or rollers.

The rotational speed of said cage may be 70 determined by providing a plurality of equally spaced apart features thereon and determining the rate at which said features pass detection means.

Said detection means may be a pulse 75 probe.

The invention will now be described, by way of example, with reference to the accompanying drawing which is diagrammatic, partially sectioned side view of a bearing assembly in accordance with the present invention. 80

With reference to the drawings, a bearing assembly generally indicated at 10 comprises a support structure 11 having an annular channel 12 which houses bearing outer race 85 13. The bearing outer race 13 is axially supported within the channel 12 by means of two "O" rings 14 which are retained within annular grooves 15 in the end faces of the channel 12.

90 Radial support and damping of the outer race 13 is provided by an oil squeeze film 16 which is fed with oil from an annular groove 17 in the radially outer face of the channel 12 which in turn is supplied with oil from an oil 95 supply duct 18. Leakage of the oil from the squeeze film 16 past the outer race 13 is prevented by the two "O" rings 14. A drain (not shown) is however provided for the outflow of oil from the squeeze film 16 so 100 that there is a continuous flow of oil through the squeeze film 16.

A plurality of rollers 19 interconnected by a cage 20 are mounted in the outer race 13. The rollers 19 also engage an inner race 105 which is constituted a shaft 21. It will be appreciated however that the inner race need not be in the form of a shaft 21 and could be of the more usual ring configuration with the rollers 19 engaging the radially outer periphery of the ring. Thus the rollers 19 and the 110 inner and outer races 13 and 21 constitute a conventional roller bearing.

The cage 20 is held together by a plurality of equally spaced apart, axially extending rivets 22. A pulse probe 23 is positioned adjacent the rivets 22 one one side of the cage 20. The arrangement is such that in operation, as the cage 20 rotates with the rollers 19, the pulse probe 23 detects each rivet 22 120 that passes by it. Each rivet 22 causes the pulse probe 23 to emit a pulse signal which is fed to a control unit 24 through a line 25. Thus the frequency of the pulses fed into the control unit 24 is proportional to the rotational 125 speed of the cage 20.

The shaft 21 is also provided with suitable means (not shown) to provide an output proportional to its rotational speed which output is fed into the control unit 24 through the line 130 26.

The control unit 24 incorporates a skid detector which determines the degree of skidding, if any, between the rollers 19 and the shaft 21. It does this by monitoring the rotational speeds of the cage 20 and the shaft 21 and computing therefrom the degree of slipping. This computation is achieved using the relationship.

$$\text{Slip} = \frac{\text{actual cage/shaft speed ratio}}{\text{epicyclic ratio}}$$

$$\text{where the epicyclic ratio} = \frac{dm - D}{2dm}$$

dm = pitch circle diameter of the rollers 19
D = roller 19 diameter.

If slipping is detected by the skid detector, the control unit 24 sends an output signal through a line 27 to a servo-valve 28 located in the oil supply duct 18. Thus if slipping is detected, the servo-valve 28 is actuated to increase the flow of oil to the squeeze film 16 from the flow rate required to merely maintain the squeeze film 16. The increased oil flow results in an increased rate of cooling of the outer race 13, thereby establishing thermal gradients within the bearing assembly 10 which result in thermal contraction of its components parts. This in turn results in the reduction of radial clearances within the bearing assembly 10, thereby reducing or substantially eliminating skidding.

Thus the squeeze film 16 serves the role of providing radial support and damping of the outer race 13 and additionally provides a variable degree of cooling to reduce or substantially eliminate skidding.

Although the present invention has been described with reference to a bearing assembly 10 which is provided with rollers 19, it will be appreciated that it is also applicable to ball bearing assemblies. Indeed with a ball bearing assembly under conditions of high load, the resulting low level of skidding or its elimination results in an increase in bearing clearance, thereby giving larger contact angles, reduced contact stresses and consequently a longer bearing life.

The present invention is capable therefore of creating bearing preload if necessary to reduce or substantially eliminate skidding but is also capable of relaxing that preload under normal operating conditions, thereby avoiding the reduction in bearing fatigue life often associated with preloaded bearings.

It will be appreciated that the flow rate of oil through the squeeze film 16 may be selected so as to suit the operating conditions of the particular type of bearing with which it is associated. Thus, for instance the control unit 24 may be set to provide an oil flow rate

which is such that a small degree of skidding is permitted under normal operating conditions. This avoids any preloading of the bearing. Moreover it will be appreciated that the squeeze film 16 is not essential to the operation of the present invention. All that is required is means for cooling the outer race 13 so that the necessary thermal gradients are established within the component parts of the bearing assembly. If the squeeze film 16 is omitted, it would of course be necessary to provide alternative means for radially supporting the outer race 13.

It will also be appreciated that although the control unit 24 has been described in relation to a single bearing assembly, it could in fact be used to control skidding in a number of different bearing assemblies.

CLAIMS

1. A ball or roller bearing assembly comprising an array of balls or roller interconnected by a cage and mounted between radially inner and outer races, said radially outer race being adapted to be cooled by a cooling fluid, regulating means to regulate the rate at which cooling fluid is supplied to said radially outer race, means adapted to detect, and indicate by means of an output signal the occurrence of skidding between said balls or rollers and one of said races, and control means associated with said skid detection means and said cooling fluid flow regulating means, said control means being so adapted as to control said fluid flow regulating means, in accordance with the output signal from said skid detection means so that cooling fluid is supplied to said radially outer race at a rate which is consistent with radial thermal gradients being established within said bearing assembly which cause sufficient thermal contraction of the component parts of said bearing assembly to reduce or substantially eliminate said skidding.

2. A ball or roller bearing assembly as claimed in claim 1 wherein said radially outer race is supported by a structure so adapted that an annular chamber is defined between them, said annular chamber being fed with said cooling fluid and so configured that said cooling fluid defines a squeeze film which constitutes the sole means of radial support between said radially outer race and said support structure.

3. A ball or roller bearing assembly as claimed in claim 1 or claim 2 wherein said cooling fluid is an oil.

4. A ball or roller bearing assembly as claimed in any one preceeding claim wherein said skid detector means comprises means adapted to monitor the rotation speeds of said cage and one of said races and to compute therefrom the magnitude of any skidding between said race and said balls or rollers.

5. A ball or roller bearing assembly as

claimed in claim 4 wherein the rotational speed of said cage is determined by providing a plurality of equally spaced apart features thereon and determining the rate at which

5 said features pass said detector means.

6. A ball or roller bearing assembly as claimed in claim 5 wherein said detection means is a pulse probe.

7. A ball or roller bearing assembly substantially as hereinbefore described with reference to the accompanying drawing.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1983.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.